OPERATING AND MAINTENANCE INSTRUCTION FOR LINE CONDITIONER MODEL 478A-3

SERIAL NUMBER _____

ACTON Laboratories, Inc.

A SUBSIDIARY OF BOWMAR INSTRUMENT CORPORATION

ACTON, MASSACHUSETTS

Acton 617-263-7756 • 531 Main Street • Boston 617-542-0284

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MANUFACTURED BY:

Acton Laboratories, Inc.
A Subsidiary of Bowmar Instrument Corporation
531 Main Street
Acton, Massachusetts U.S.A. 01720
Telephone: 617-263-7756

Rev. 1

January 1970

WARNING

HIGH VOLTAGE

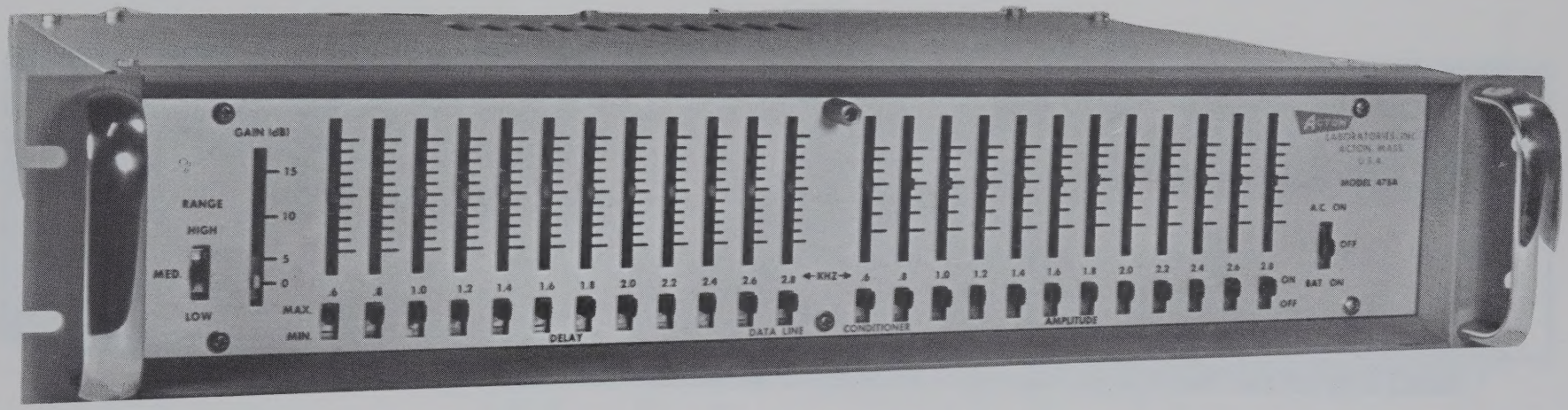
is used in this equipment

Be careful when working on the AC line connections or the chassis assembly of this equipment. Voltages as high as 230 volts may be present. Serious injury or death may result from contact with exposed terminals and connections.

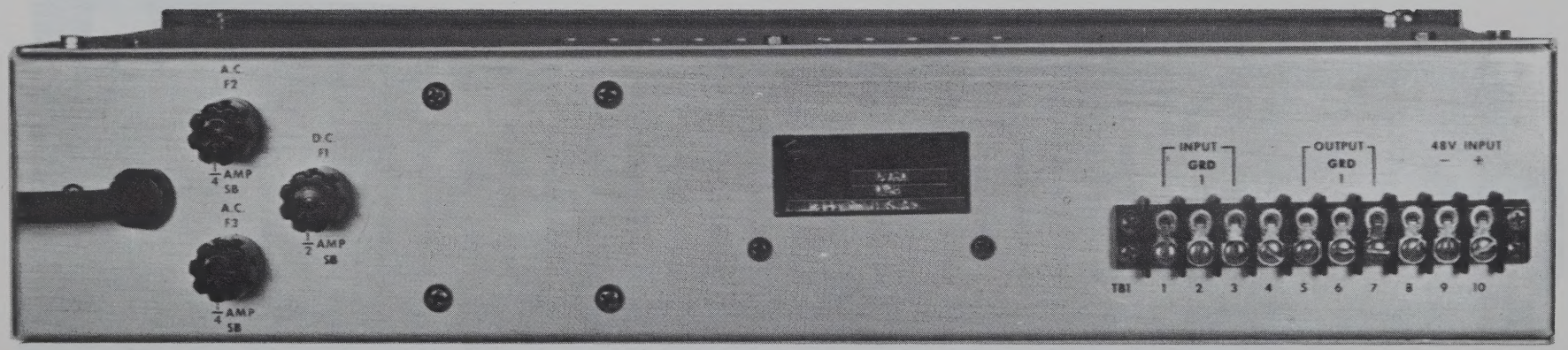
DON'T TAKE CHANCES!

IMPORTANT

This instrument is designed to operate from power sources of 115 or 230 VAC, at frequencies from 47 to 63 Hz and from -48 VDC. Unless otherwise directed, shipments from the factory are made with the instrument connected for 115 VAC.



Data Line Conditioner 478A



Data Line Conditioner 478A

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SECTION 1

INTRODUCTION

1.0 Introduction

1.1 Description

The Acton Laboratories' Model 478A Line Conditioner is designed to provide compensation for envelope delay and amplitude distortion existing in voice frequency lines and channels. The unit is normally used in conjunction with a measuring set, such as the Acton Laboratories' 462 and 490 series, which can measure the compensation characteristics that the conditioner must provide.

1.2 Scope of Manual

This operation and maintenance manual describes the various operations commonly employed in the compensation of amplitude and delay characteristics of transmission systems and networks. Also included are complete schematics, layouts, calibration procedures, and circuit descriptions to assist technical personnel in the field maintenance of the units. In addition, a complete electrical parts list with manufacturers' part numbers and addresses of manufacturers are provided to assist in the procurement of exact replacement parts when necessary.

1.3 Designation of Instruments

The series designation for these instruments is 478A. Within this generic 478A series certain modifications are made for specific customer requirements and periodically incorporated for design improvements. As each major modification or improvement is incorporated, a "dash number" or letter may be added to the series number to indicate a specific model. For example, a specific instrument may be designated 478A-1 or 478A-2, etc. These numbers precisely describe the instrument currently in production. This number, along with a serial number appearing on the rear nameplate of each unit should be referred to in all correspondence relating to the instruments.

1.4 General Background Information

Any communications medium (wire, radio, microwave, coaxial cable, etc.) will degrade a signal passing through it because of at least three significant distortions.

a. Amplitude variation with frequency. Typical circuits invariably have a high frequency cutoff, and may have a low frequency limitation.

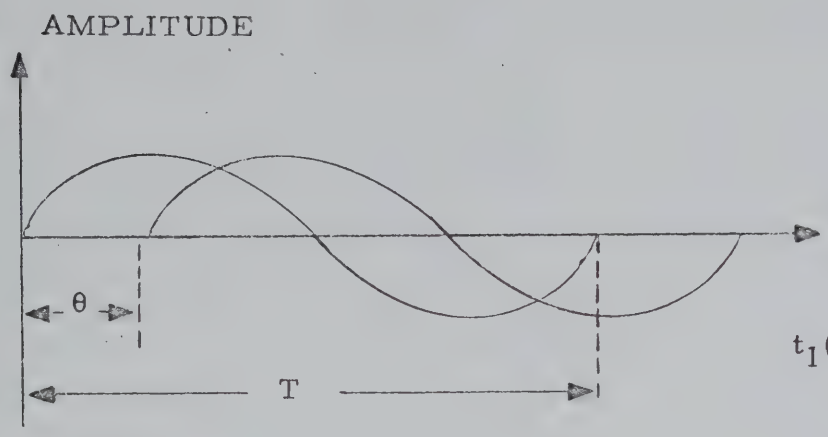
b. Phase Distortion. If the transmission medium has a phase shift characteristic that is not linear -- i.e., if phase shift is not directly proportional to signal frequency, an effect known as delay distortion occurs.

c. Non-Linear Amplitude Response. The system may have a response which is not linear with level, leading to harmonic and intermodulation distortion.

Since amplitude vs. frequency response characteristics are relatively well known. This technical note is primarily concerned with an explanation of the delay (phase) distortion.

The delay distortion of a transmission system is somewhat more difficult to understand than amplitude response, but it is nevertheless an extremely important parameter. If delay distortion is present, certain frequencies in a signal band will be delayed more than others. The effects of this differential delay on a system depends of course, on the information characteristics. For instance, moderate amounts of delay distortion have comparatively small effects upon voice transmission, since the ear is not particularly sensitive to phase variations. On the other hand, differential delay on a channel used to transmit complex information such as radar video, television, facsimile, or digital data can result in a large degradation of the received signal. Delay distortion on a high-speed digital link can result in a prohibitive error rate, or a completely unuseable channel. The present trend toward increased usage of communications channels for high speed transmission of coded data results in an increasingly critical need for evaluation of delay distortion in any communications system.

The simplest form of time delay to visualize and understand is the absolute transmission delay of a signal traveling from one point in a circuit or system to another. When the signal is a single pulse or a burst of pulses, the absolute time delay can be determined. A dual trace oscilloscope with a common synchronization trigger can be used to make this measurement. The oscilloscope measurement may be read directly in terms of time, or in the case of a sinewave, time can be computed by a knowledge of phase shift and frequency. The time delay is proportional to the phase shift divided by the frequency as shown in the following diagram.

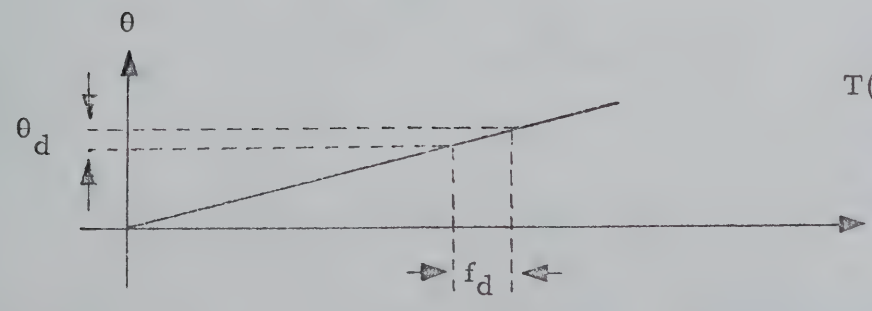


θ - phase shift in degrees
T - Time Period
f - frequency (f = 1/T)

$$t_1(\text{delay}) = \frac{\theta}{360} T$$

When a continuous sinewave or band of sinewaves is being transmitted, the concept of absolute time delay becomes nebulous, since it is impossible to observe a single wave front or pulse. An oscilloscope displayed pattern could show time delay only within a cycle of the signal frequency. A time delay read as t_1 could actually be $t_1 + nT$, where n is any integer and T is the time period of the signal.

In actual practice, for perfect data transmission it is only necessary that all frequencies in the information band be delayed by the same amount of time. No arbitrary amount of time delay has to be realized. The constant time delay associated with this ideal transmission system will only cause a time delay in the reception of the information, but no distortion. The requirement for a constant delay for all frequencies in a band can be interpreted as requiring a constant differential phase shift vs. frequency as shown in the following diagram.



$$T(\text{delay}) = \frac{\theta_d}{360\, f_d}$$

Constant Time Delay

The phase characteristics outside the frequency band may have any shape without affecting the information transmission.

For perfect data transmission a line must have a flat or constant envelope delay and also a flat amplitude response vs. frequency. Since the time delay cannot be subtracted, equalization or corrective networks must add delay so that the composite characteristics of a line with phase distortion and the equalization networks yield a flat response over the bandwidth of interest. The following figure shows the delay characteristics of an arbitrary line. To provide a perfectly corrected delay curve, an inserted corrective network must have the inverse delay characteristics of the line. The task, therefore, is to raise the delay of all points to the level of the highest delay value of the uncorrected line. The amplitude response vs. frequency must also be compensated for, by the equalization network. The references to equalizing a line can be applied to equalization of any circuit or network.

1.5 Specifications

Frequency Band: 300 Hz to 3400 Hz

Input/Output Impedances: Selectable at 600 or 900 ohms, Balanced and Floating

Longitudinal Balance: 40 dB minimum

Return Loss: 26 dB max. (±10% impedance tolerance)

Input Level: +10 to -35 dBm

Broadband Gain: Continuously adjustable over each of three selectable ranges:

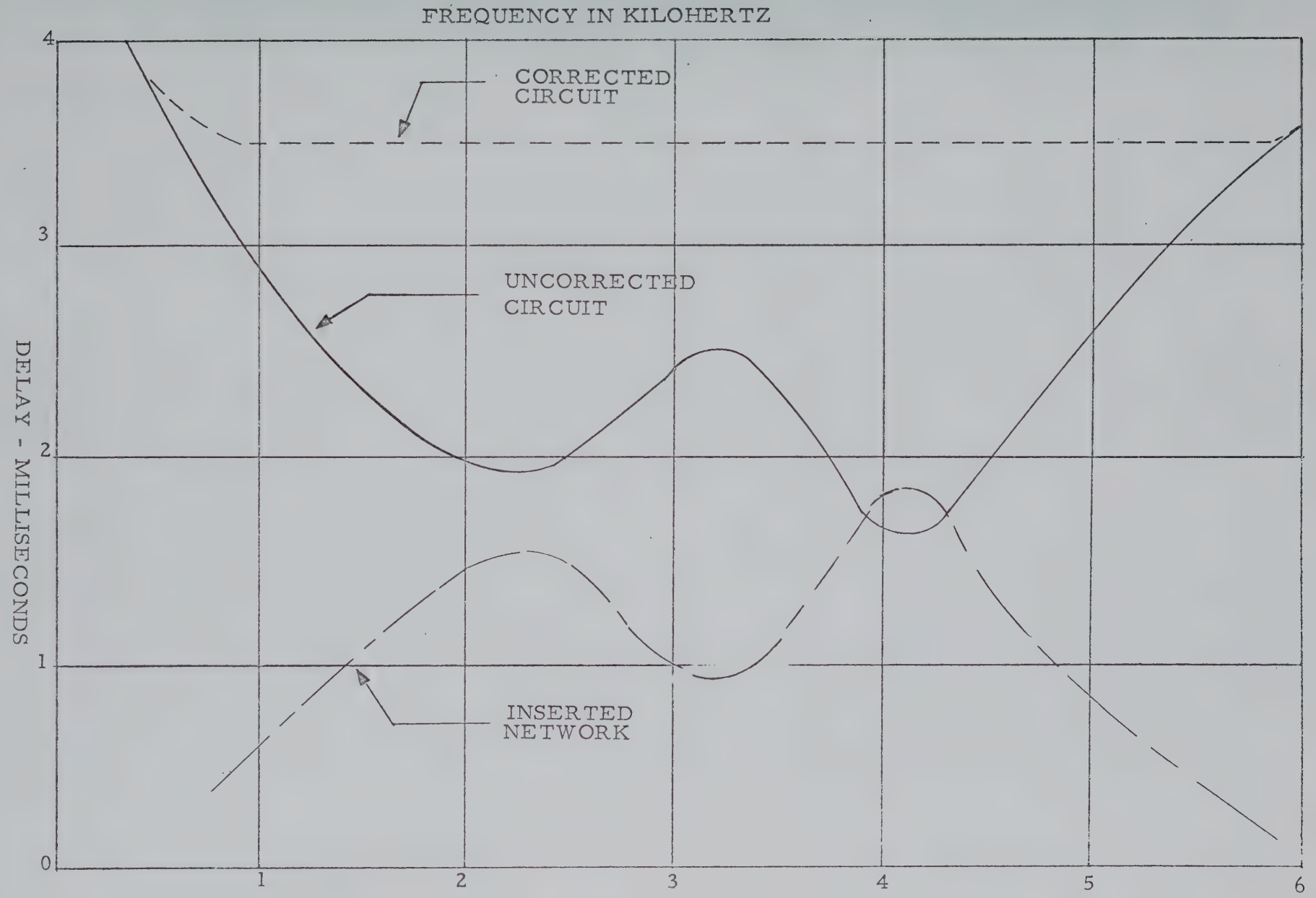
High	+20 to +35 dB
Medium	+5 to +20 dB
Lo	-10 to +5 dB

Output Level: +10 dBm maximum

Number of Sections: 12 amplitude and 12 delay

Section Frequencies: 600, 800, 1000, 1200, 1400, 1600, 1800 2000, 2200, 2400, 2600 and 2800 Hz

Alternate Frequencies: The center frequency for any section except 600 Hz may be lowered 100 Hz by change of an internal wire strap.



DELAY EQUALIZATION - EXAMPLE

Delay Range Per Section:	Each section has individual switch for selection of 1.4 or 2.5 Ms delay full scale. Each range continuously adjustable.
Delay Interaction on Amplitude:	Less than 0.1 dB at resonant frequency of section.
Amplitude Range Per Section:	±3 dB, continously adjustable

Output Noise: -65 dBm max., 300 Hz to 3400 Hz

Operating Temperature: 0° to 50° C. (32° F. to 120° F).

Operating Humidity: 0 to 95% relative

Primary Power: 115/230 VAC ±10%, 47 to 63 Hz single phase or -48 VDC (Reverse polarity protection provided on -48V).

Power Consumption: 6 to 10 watts AC or -48VDC, approximately 110 mA, depending upon control settings.

Dimensions: Standard 19" rack mount, 3 1/2" H. x 11" D.

Weight: 11 lbs. approximate

SECTION 2

2.0 OPERATING INSTRUCTIONS

2.1 Functions of Controls and Connectors

2.1.1 Front Panel Controls

Power: 3 position slide switch which controls application of power to unit. External ac power is applied when in the A. C. ON (up) position; unit is off when in the OFF (mid) position; external -48V dc power is applied when in the BAT. ON (down) position.

RANGE: 3 position slide switch which controls the broadband gain range. The three ranges are:

HIGH	+20 to +35 dB
MED.	+5 to +20 dB
LOW	-10 to +5 dB

GAIN (dB): slide control which gives continuous gain adjustment over any of the 15 dB gain ranges. The scale has nominal divisions at the 0, 5, 10, and 15 dB gain points. Gain from input to output of the unit, exclusive of individual section gains, is as follows:

HIGH RANGE	20 dB + GAIN (dB) slide setting
MED. RANGE	5 dB + GAIN (dB) slide setting
LOW RANGE	-10 dB + GAIN (dB) slide setting

DELAY: 12 slide controls which permit continuous adjustment of amount of delay correction inserted per section. Moving lever upward increases delay.

MIN.-MAX.: 12 delay selector switches which permit selection of two ranges of delay for each section, either 1.4 ms for MIN. or 2.5 ms for MAX.

AMPLITUDE: 12 slide controls which permit continuous adjustment of the amount of amplitude correction inserted per section. Range is nominal $\pm$ 3 dB. All Pass, or Flat, position is with control lever near center scale division.

ON-OFF: 12 section/slide switches which permit the selection of either on or off for each section. The switches affect both delay and amplitude for this section.

2.1.2 Rear Panel Controls and Connections

Terminal Board 1:

1. INPUT Signal	6. Chassis GRD
2. Chassis GRD	7. OUTPUT Signal
3. INPUT Signal	8. ----------
4. ----------	9. -48 V INPUT
5. OUTPUT Signal	10. -48 V INPUT (Chassis Grd)

Fuse, F1: 1/2 A fuse for -48 V dc input line.

Fuses, F2 and F3: 1/4 A slow blow fuses for ac input lines.

2.1.3 Internal Controls and Connectors (See Drawing 478-101)

Power Selector: internal slide switch which permits selection of 115 V or 230 V ac nominal. Switch requires insertion of screwdriver blade to operate. Units are shipped from the factory with the selector switch at 115 V unless otherwise specified.

600/900 Ohms Impedance Select Terminals: Two sets of terminals which permit selection of either 600 or 900 ohm nominal input and output impedances.

Section Delay Peak Frequency Select Terminals: 11 sets of terminals which permit the individual sections to be lowered nominal 100 Hz from their designated frequencies.

2.2 Operating Procedures

2.2.1 General Information

Before putting the unit into operation, check that the power source agrees with that specified for the unit. The unit may be operated as received from the factory if 115 V ac, 47-63 Hz, is available; remove the top cover and change S4 to the 230 V position for operation at this voltage.

If a -48 V dc station battery supply is used, it is necessary to wire it to the proper terminals on the barrier strip at the rear of the unit.

No special precautions or calibrations are necessary; however, reasonable care should be exercised not to place units in locations where environmental conditions will exceed those specified.

A block diagram of a typical set-up used for equalizing a line is shown on the following page. This connection is commonly referred to as an end-to-end measurement; however, other connections such as forward reference and return reference may be employed.

Refer to the individual operating instructions of the measuring set in use for the detailed methods. When making equalization adjustments, there should be a set of specifications for the delay and amplitude characteristics after equalization. As the signal at the transmit end is varied, the controls of the line conditioner are adjusted for delay and amplitude characteristics that meet or exceed the specification.

The use of an X-Y recorder is especially helpful as a visual aid in the equalization procedure. Frequency is typically displayed on the X coordinates, and amplitude or delay on the Y coordinates. The analog outputs of the measuring set are connected to the recorder and calibrated, then, as the frequency of interest is swept, the traces can be adjusted for desired performance. Even though the successive traces may tend to overlap and appear confusing, an operator can easily distinguish where compensation is necessary.

2.2.2 Detailed Equalization Procedure

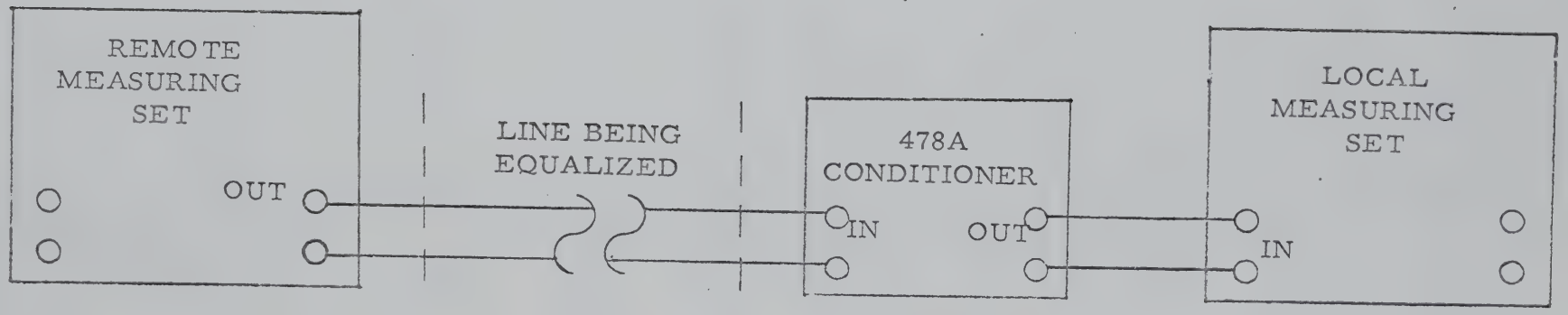
2.2.2.1 Initial Steps

a. A typical equipment arrangement used to equalize a line is shown as part of Para. 2.2. In this arrangement, the line conditioner is connected between the output of the line to be equalized and the delay measuring set.

b. Initial Control Settings of line conditioner.

Delay MIN-MAX switches - MAX
DELAY Slide Controls - upper limit
Section ON-OFF switches - OFF
AMPLITUDE Slide controls - mid gain positions per panel markings.

NOTE: Make certain that the selected input and output impedances (Sec. 2.3) match those of the connected system, and that the general conditions of Para. 2.2.1 have been met.



TYPICAL EQUIPMENT ARRANGEMENT

c. Set the GAIN slide control to provide the proper output signal at the middle of the band.

d. Measure the delay and amplitude characteristics of the line.

e. Plot the data to obtain the delay and amplitude characteristics.

NOTE: When an envelope delay distortion measuring set such as the Acton Laboratories' 462 or 490 series is used, the delay and amplitude characteristics can be obtained directly on an X-Y recorder by taking signals from the analog output terminals of the measuring set.

2.2.2.2 Amplitude Equalization

a. Switch "ON" the sections and operate AMPLITUDE slide controls as necessary to attain the desired amplitude characteristics across the band. Since individual sections have gain shapes that overlap, it may be necessary to repeat the adjustment of each section several times.

2.2.2.3 Delay Equalization

a. Delay equalization is normally accomplished by inserting delay in the amount required to equal that measured at the edges of the frequency band of interest.

b. Turn "ON" one delay section whose frequency is near the center of the band (This section may already have been turned "ON" for amplitude equalization).

c. Move the DELAY slide control to adjust the delay at this frequency to equal the delay at the edges of the band.

d. Repeat this procedure at frequencies approximately 1/4 and 3/4 of the band.

e. Operate the remaining delay sections as necessary to flatten the delay vs. frequency characteristics.

f. It may be necessary to go back and readjust the delay settings of each section several times since the delay shapes overlap.

2.3 Changing Input and Output Impedances and Delay Peak Frequencies

2.3.1 Drawing (478-101) shows the location of the terminals to which wire straps are attached to change the input and output impedances and shift the frequencies of peak delay for each section.

2.3.2 The input and output impedance straps are shown connected for 600 ohms. To change these impedances to 900 ohms it is necessary to remove the straps from the 600 ohm terminals and connect them to the 900 ohm terminals.

2.3.3 The frequency at which peak delay occurs (f_o), as indicated on the front panel may be shifted down by 100 Hz (to f_o-100Hz). This is accomplished by changing the strap connection for the particular section. Drawing (478-101) shows the location of the terminals and the strap connections. The straps are shown for peak delay at f_o.

NOTE: The lowest frequency section may not have the capability of being lowered further in frequency. (See Paragraph 1.5 under Alternate Frequencies).

SECTION 3

CIRCUIT DESCRIPTION

3.0 Circuit Description

3.1 Introduction

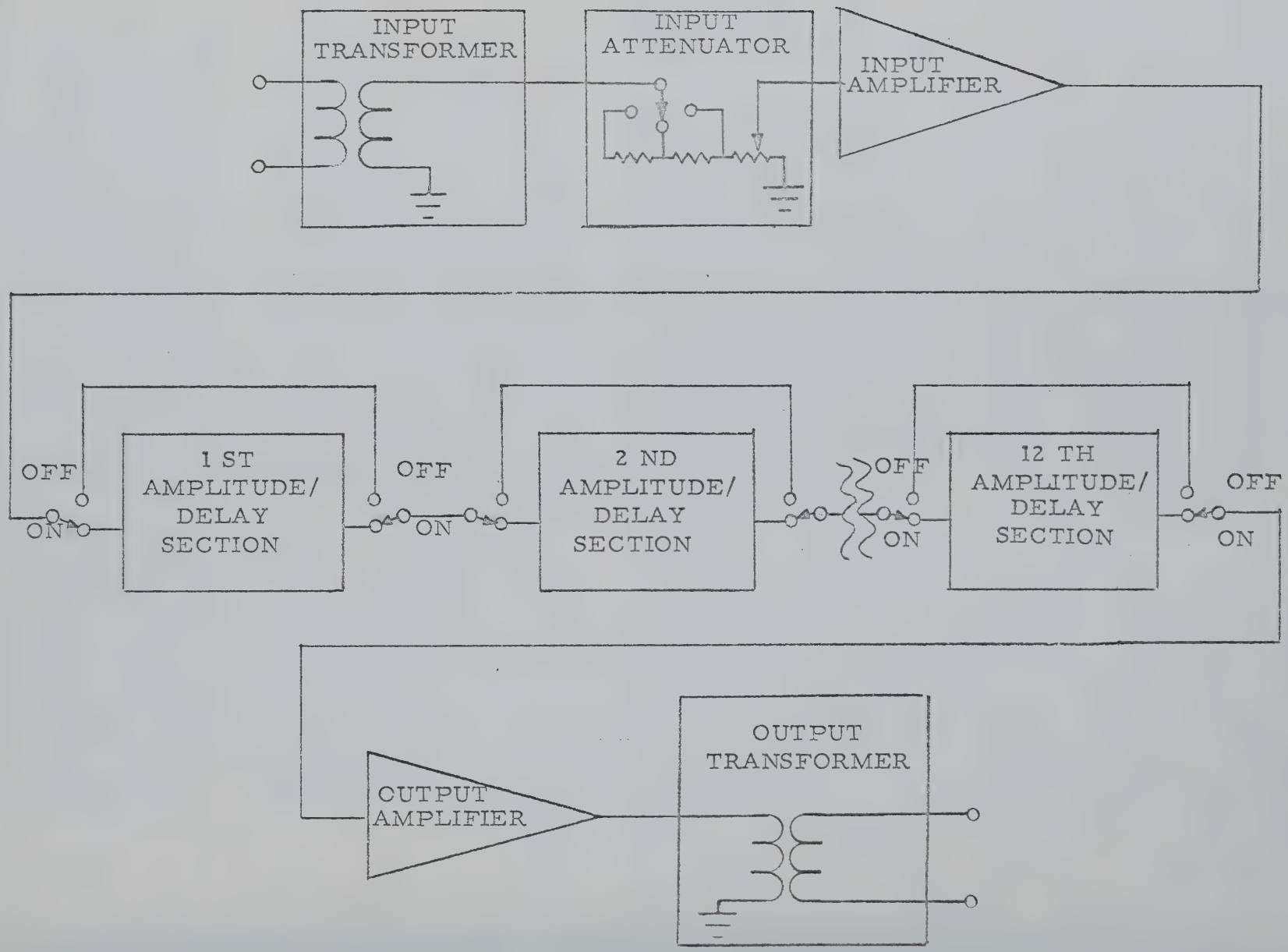
A block diagram of the 478A-3 Line Conditioner is shown on the following page. The unit is functionally comprised of broadband input and output amplifiers and twelve individual amplitude/delay sections. Transformer coupling provides floating input and output connections. The broadband gain of the unit is controlled via the input attenuator which provides gain control between -10 and +35 dB in three 15 dB ranges. Each amplitude/delay section has a switch at the input so that the section may be switched into the signal path or bypassed. Seperate amplitude and delay controls are provided for each section.

3.2 Detailed Circuit Description

The schematic diagram for the 478A-3 is shown in drawing D478-002. Signals are coupled to the input amplifier through transformer T1, and the input attenuator comprised of switch S5, resistors R1, R3, R21 through R25, and potentiometer R2. Switch S5 sets the nominal range of adjustment of potentiometer R2 at 6 - 21, 21 - 36, or 36 - 51 dB. The input impedance to the unit is determined by the strap connection to R50 or R51. Connection to R51 sets the impedance at 600 ohms and connection to R50 sets the impedance at 900 ohms.

The input amplifier is comprised of transistors Q1 through Q6. The circuit is basically a direct coupled operational amplifier with Q1 and Q2 as the differential input stage. Q3 provides additional gain and Q4 serves as a low output impedance driver for the complementary output stage Q5 and Q6. Feedback is provided through R19, R20, R9 and R4. This network sets the overall voltage gain at 30 dB.

The delay section amplifiers are identical as shown for Delay Section 1. This circuit may be considered as an operational



478A LINE CONDITIONER

amplifier with inverting input to 1Q1, and non-inverting input to 1Q2. A resistive network comprised of 1R1 and 1R5 is connected to the inverting input and a delay network (DEL-AMP-DAI) is connected at the non-inverting input. 1R1 is a slide potentiometer used to control the gain of the amplifier over a nominal ±3 dB range. The delay network, in conjunction with 1R15, 1R16, and 1R17, controls the delay of the section. Potentiometer 1R17 is the Delay slide control which appears on the front panel. Transistors 1Q1 and 1Q2 operate as a single ended differential amplifier. The signal at the collector of 1Q2 is delayed and has an amplitude determined by the settings of potentiometers 1R17 and 1R1. Transistor 1Q3 provides additional gain and shifts the DC level to drive the output emitter follower, 1Q4. The switches at the input and output of the delay sections permit switching the section in or out of the signal path.

The output amplifier provides a total voltage gain of 13 dB. The input stage to this amplifier is a balanced differential stage comprised of Q14 and Q15. The output of Q15 is direct coupled to Q16 which serves to provide additional gain and shift the DC level to drive the complementary output stage Q17 and Q18. Negative feedback is provided through R27 to set the voltage gain at +19 dB. The output impedance of the amplifier is determined by R41 or R42 in series with the low output impedance of the output stage A17 and Q18. This results in a 6 dB voltage loss so that the total voltage between the input to Q14 and output at transformer T3 is +13 dB.

The DC power to operate the unit may be derived from 115 or 230 VAC or -48 VDC. The AC line voltages are connected through the protective fuses F2 and F3, Switch S3 and S4 to Transformer T2. Switch S4 permits selection of 115 or 230 VAC operation by connecting the primary windings of T2 in parallel or series. Switch S3 permits selection of OFF, AC or BATT operation. When in the BATT position, an external -48 VDC source may be connected to the power supply filter and regulator.

When the unit is operated with AC line voltages, the bridge rectifier CR4 provides a full wave rectified output which is filtered through C5 and R43 and connected to a voltage regulator circuit consisting of Q7, Q8, and Q9. When the unit is operated from an external

-48 VDC supply, the voltage is connected to the regulator through diode CR3 which protects the circuit from damage due to accidental reverse polarity.

Voltage regulation to -30V is obtained through the action of CR5 and Q9 which control the collector-to-emitter voltage drop across the Darlington coupled pair, Q7 and Q8. If the voltage at the emitter of Q8 decreases, the voltage at the base of Q9 also decreases, resulting in more base current for Q7 and Q8 and drops the collector to emitter voltage.

The complementary series connected transistors, Q13 and Q12 are used to derive the -15 volt supply voltage used as a reference in the direct coupled amplifiers. Q10 provides regulation to maintain the output at -15 volts by virtue of the voltage fed back through R56.

SECTION 4

TEST AND CALIBRATION

4.0 Test and Calibration

4.1 Test Equipment

The following test equipment (or equivalent) is required for testing the Line Conditioner.

Acton Laboratories	462A or 490B	Envelope Delay Measuring Set
Ballantine	310B	Vacuum Tube Voltmeter
Tektronix	545	Oscilloscope
Triplett	630NA	Voltohm Meter
General Radio	1151AP	Frequency Counter
Hewlett Packard	350D	600 Ohm Attenuator

4.2 DC Voltage Measurements

Measure the -30 and -15 volt DC supply potentials. Points for these measurements (GRD, -15V, -30V) are indicated on the top side of the printed wiring board at the rear and are accessible after removing the top cover. The -30V supply should be between -27 and -33 volts and the -15 volt supply should be between -13.5 and -16.5 volts.

With all delay section ON-OFF switches at OFF, measure the DC voltages at the outputs of the input and output amplifiers and each delay section amplifier. Points for these measurements are as follows:

DC Voltage Measured	Connect Voltmeter Between
Output of Input Amplifier	GRD and junction of R17 and R19
Output of Delay Section Amplifier	GRD and junction of R5 and R14
Output of Output Amplifier	GRD and junction of R27 and R38

These voltages should be between -13 and -17 volts.

4.3 Input and Output Amplifier Gain Measurements

4.3.1 Initial Steps

Set the Line Conditioner controls as follows:

Input and Output Impedance	600 Ohms
GAIN Slide Control	Fully up (max. gain)
Section ON-OFF Switches	OFF
Section AMPLITUDE Slide Controls	Mid-position, per panel marking
Section Delay MAX-MIN Range Switches	MAX
Section DELAY Slide Controls	Fully up (Max. Delay)

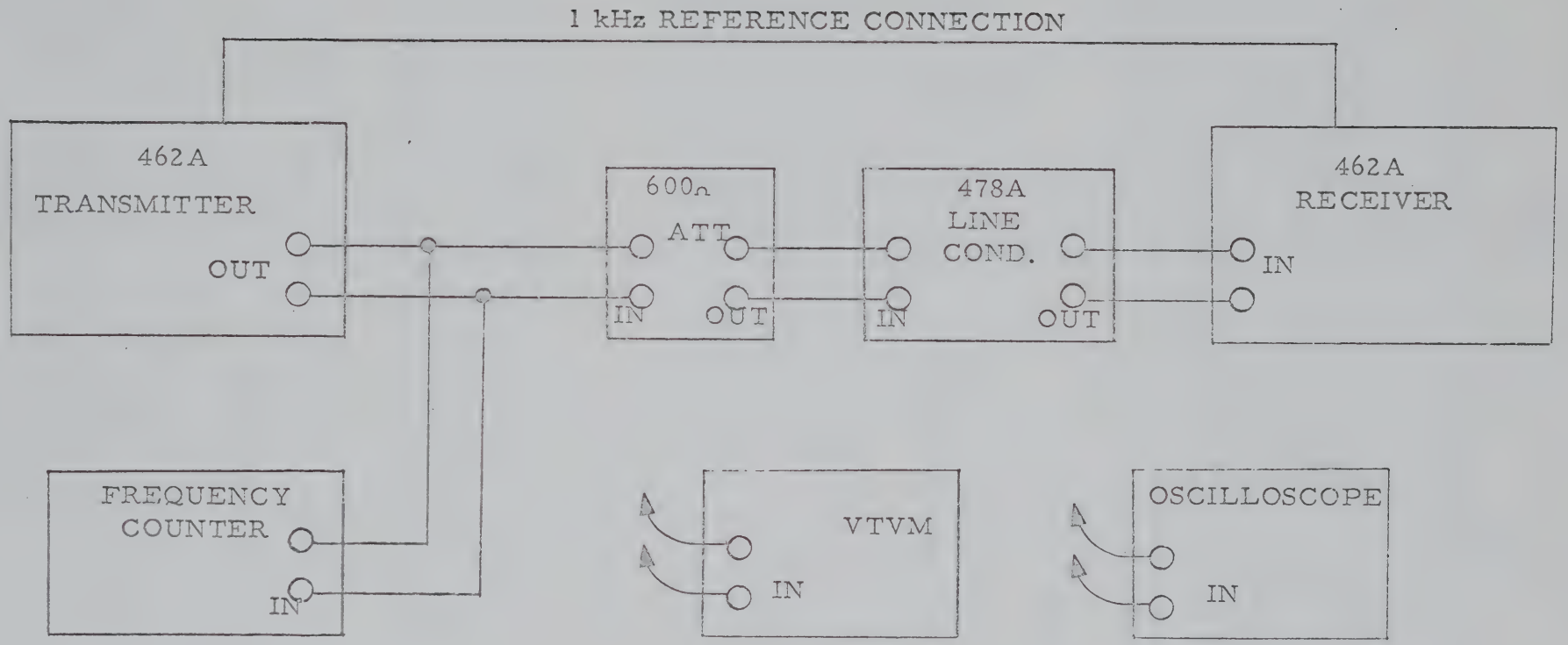
Connect the test set-up as shown on the following page. Set the delay measuring set controls for a continuous wave output at a frequency of 1 kHz. Adjust the signal amplitude for -30 dBm (0.0245 Vrms) measured at the input to the Line Conditioner.

4.3.2 Input Amplifier Gain

Measure the input amplifier gain by taking the difference in dB between the -30 dB signal at the input to the line conditioner and the voltage measured between the emitter of Q5 and ground. The gain should be between 18 and 22 dB. (Be sure that the GAIN slide control is fully up for maximum gain.)

4.3.3 Output Amplifier Gain

Measure the output amplifier gain by taking the difference in dB between the signal voltage as measured between emitter of Q5 and ground and across the output terminals of the line conditioner. The gain should be between 11 and 15 dB. (Be sure the line conditioner has a 600 ohm load provided by a delay measuring set or 600 ohm resistor).


1 kHz REFERENCE CONNECTION
462A
TRANSMITTER
OUT
600Ω
ATT
IN
OUT
478A
LINE
COND.
IN
OUT
462A
RECEIVER
IN
FREQUENCY
COUNTER
IN
VTVM
IN
OSCILLOSCOPE
IN

TEST SET-UP

4.4 Amplitude/Delay Section Measurements

4.4.1 Initial Steps

The diagram "TEST SET-UP" shows the connections for checking the performance of the amplitude/delay sections in the Line Conditioner. Set the controls as given in 4.3.1. Using the GAIN slide control adjust the output from the line conditioner to 0 dBm (0.775 Vrms). Set the controls on the delay measuring set to use the lowest modulating frequency and establish zero reference delay at a frequency of 1kHz.

4.4.2 Delay Range

Operate the lowest frequency amplitude/delay section ON-OFF switch to ON. Adjust the delay measuring set carrier frequency for maximum delay as observed on the delay meter. The delay should be 2.5 ms or greater. Observe the frequency as indicated by the frequency counter. The frequency should be within ±1.5% of that specified for the section. Switch the delay MAX-MIN switch to MIN and measure the delay. The delay should be greater than 1.5 ms. Check the operation of the DELAY slide control by moving it downward slowly while observing the delay meter. The delay should decrease smoothly as the control moves down.

4.4.3 Amplitude Range

Connect the VTVM at the output of the line conditioner and move the section AMPLITUDE control fully down. Note the signal voltage. Move the section AMPLITUDE slide control fully upward and again note the signal output voltage. The voltage should have increased by at least 6 dB (doubled.)

4.4.4

Repeat 4.4.2 and 4.4.3 for the remaining delay sections using the applicable center frequency for each of the sections.

4.5 Output Signal Swing

Set the line conditioner controls as given in 4.3.1 except set the GAIN slide control at its approximate mid-position. Set the delay measuring set controls for a 1 kHz continuous wave signal output. Adjust the signal amplitude, as measured at the input to the line conditioner for -10 dBm (0.245 Vrms.) Connect

the oscilloscope at the output of the line conditioner. Set the oscilloscope time base for 0.2 ms per division and vertical sensitivity for 2 volts per division. On the Line Conditioner, move the GAIN slide control slowly upward (increasing gain) while observing the signal waveform on the oscilloscope. Note the peak to peak voltage at which the waveform just starts to become sharply distorted. This voltage should be greater than 6.9 volts peak to peak (2.45 Vrms).

SECTION 5

DRAWINGS

5.1 General

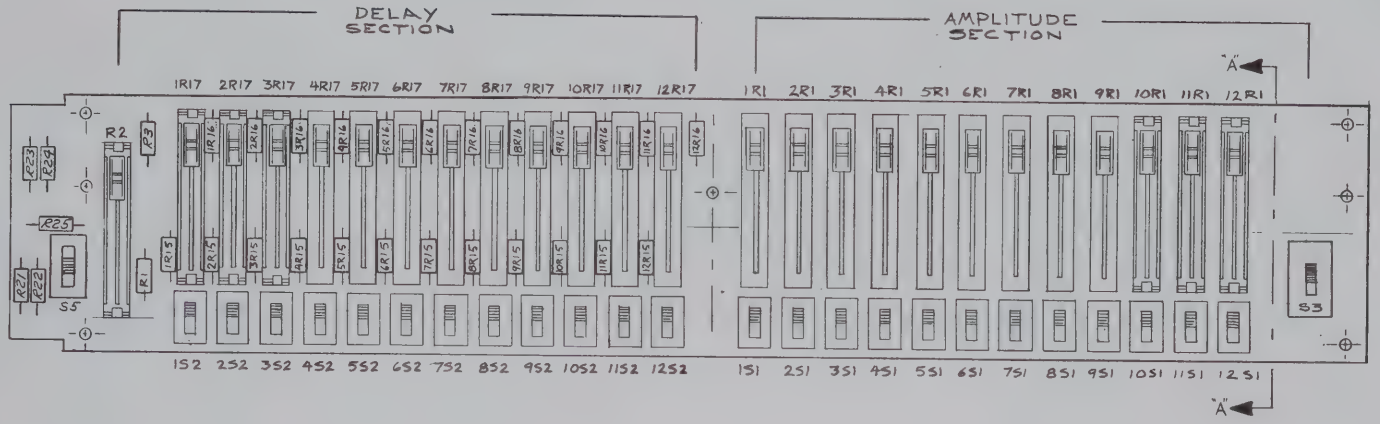
In this section are contained all the schematics, wiring diagrams, location, and layout drawings necessary to assist the field engineer or technician in the maintenance, calibration and use of this equipment.

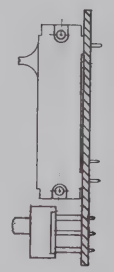
Front Panel Board, Assembly C478-100

Data Line Conditioner
Main Board, Assembly C478-101-2

Data Line Conditioner,
Schematic D478-002-2

REVISIONS			
SYM	DESCRIPTION	DATE	APP
0	DRAWING RELEASED	1/14/69	DWB
A	ADDED S4 TO FRONT PANEL DCN 258	1/21/69	DWB
B	ADDED R21, R22, R23, R24, R25 & S5 DCN # 412 AB	1/9/69	





SECTION "A-A"

NOTE

1. FOR LIST OF MATERIAL SEE LMC478-100.-3
2. FOR SCHEMATIC SEE D478-002.-2.

C478-100 B

REQD	ITEM	PART NO.	DESCRIPTION

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED	DR	W.Y. 12.30.68
ALL DIMENSIONS IN INCHES	CHK	DWBirche 1/14/69
STANDARD TOLERANCES FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2°	ENG	Jdt 1/14/69
FINISH TURNING TO .003 T I R ALL PIECES MUST BE CLEAN AND FREE FROM BURRS. ALL THREADS CL-2.75% TH'D MIN.	APP	
	MATERIAL	
USED ON 478 A -3	FINISH	

TITLE

FRONT PANEL BOARD ASSEMBLY

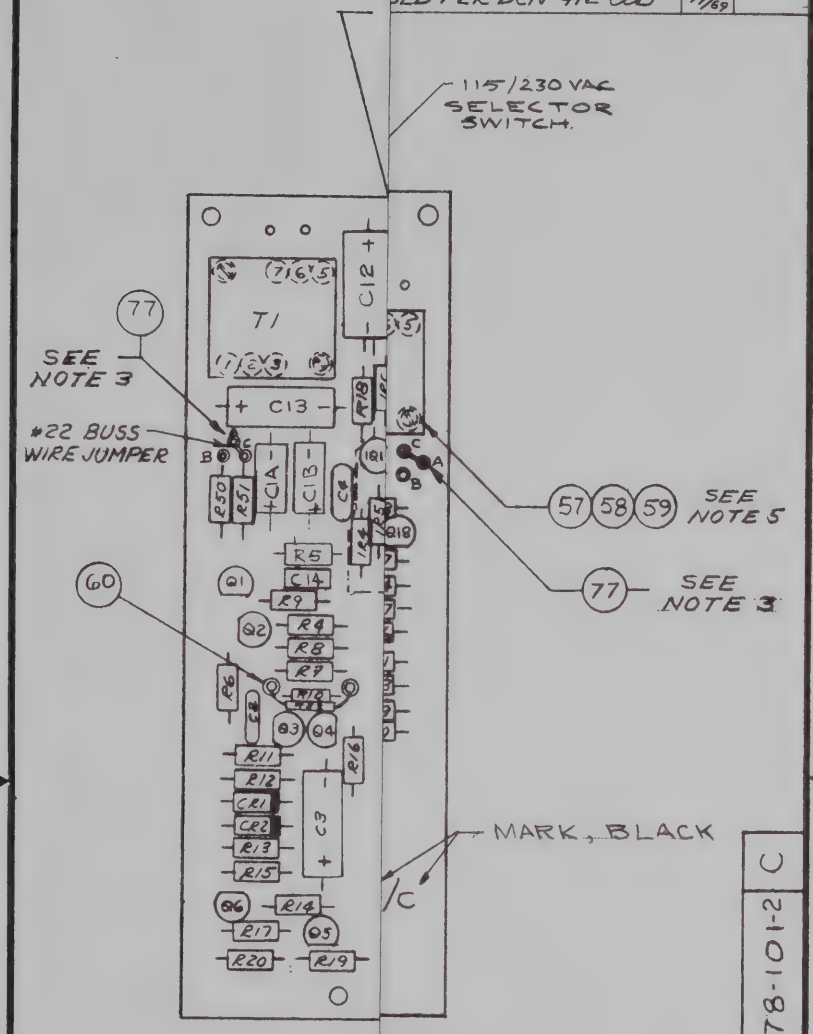
ACTON LABORATORIES, INC.
ACTON, MASS., U.S.A.
SUBSIDIARY OF BOWMAR INSTRUMENT CORP.

DWG. NO. C 478-100 REV B

SCALE FULL | CODE #03860 | SHEET 1 OF 1

ACTON PRESS

REVISIONS		
DESCRIPTION	DATE	APP
WING RELEASED	4/2/69	
ED PER DCN 339	5·14 69	DWB
SED TERMINAL MARKING DCN 376	7/17/69	DWB
SED PER DCN 412 CAB	10/1/69	



C478-101-2 C

NOTES:

1. FOR LIST OF MAT
2. FOR SCHEMATIC
3. JUMPERS ARE S
   FOR 900 OPER
   FROM
4. JUMPER IS SHO
   FOR OPERATING
   FREQUENCY
   AND ATTAC
5. ITEMS 57, 58 &
   D

NE
ONER
MBLY

NO.	DESCRIPTION
	LIST OF MATERIAL

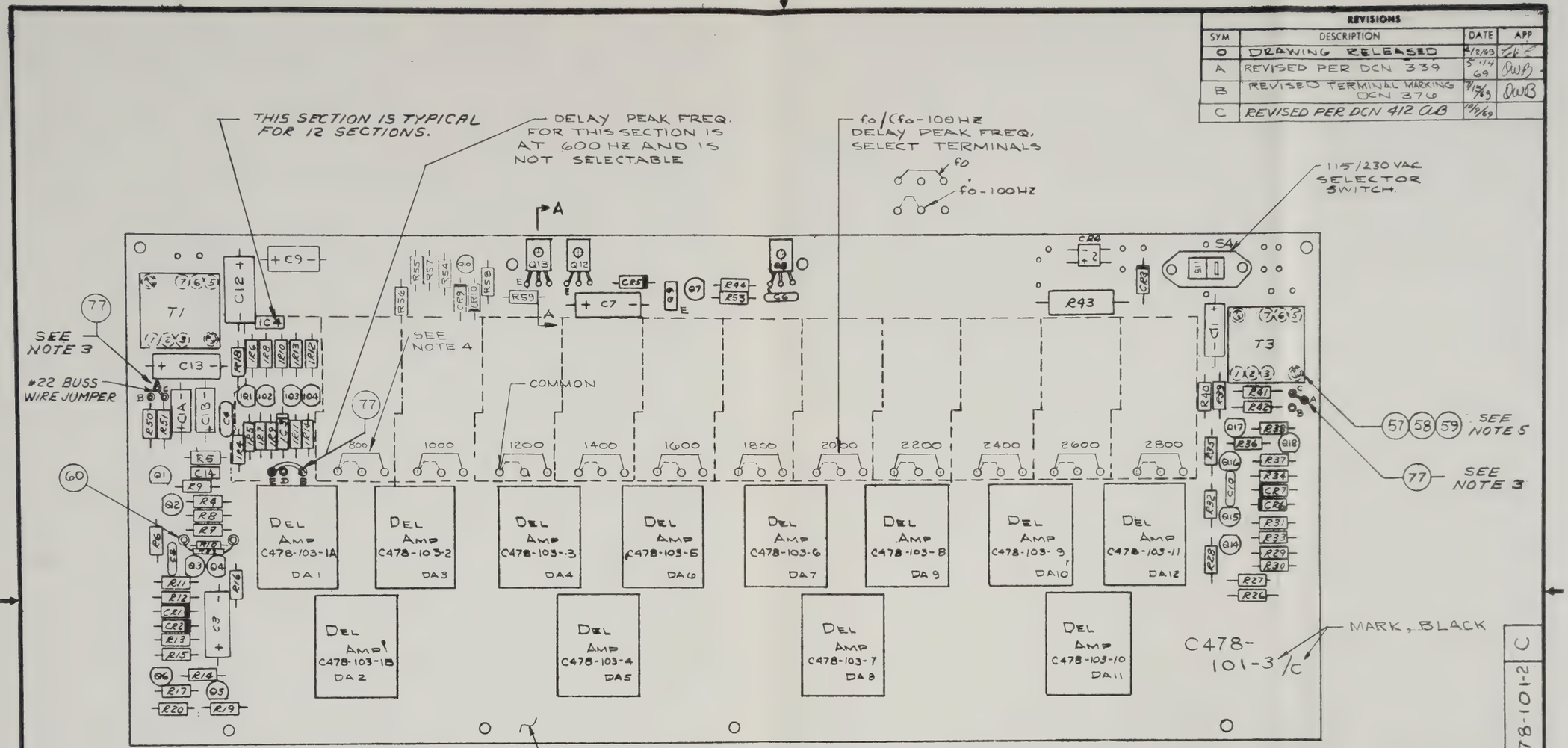
ACTON LABORATORIES, INC.
ACTON, MASS., U.S.A.
SUBSIDIARY OF
BOWMAR INSTRUMENT CORP.

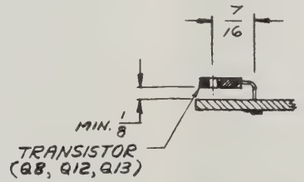
DWG. NO. C478-101-2 REV C

CODE #03860 SHEET 1 OF 1

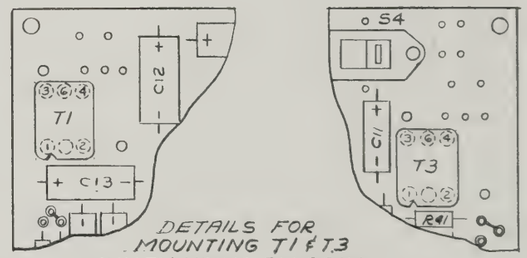
ACTON PRESS

REVISIONS			
SYM	DESCRIPTION	DATE	APP
0	DRAWING RELEASED	4/2/69	
A	REVISED PER DCN 339	5/14/69	
B	REVISED TERMINAL MARKING DCN 370	7/17/69	
C	REVISED PER DCN 412 CJB	10/15/69	





VIEW AT A-A



DETAILS FOR MOUNTING T1 & T3 WHEN USING ALLADIN TYPE TRANSFORMERS.

NOTES:

1. FOR LIST OF MATERIALS SEE: LM C478-101-3
2. FOR SCHEMATIC SEE: D478-002-2
3. JUMPERS ARE SHOWN FOR 600Ω OPERATION. FOR 900Ω OPERATION CHANGE JUMPERS TO GO FROM "A" TO "B". "C" IS 600Ω, "B" IS 900Ω
4. JUMPER IS SHOWN FOR NOMINAL OPERATION. FOR OPERATING 100 HZ LOWER THAN NOMINAL FREQUENCY REMOVE JUMPER FROM "B TO E" AND ATTACH FROM "D" TO "E".
5. ITEMS 57, 58 & 59 NOT USED WITH ALLADIN TRANSFORMERS. (T1 & T3).

REQD	ITEM	PART NO.	DESCRIPTION

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED	DR	CJB 12/16/68
ALL DIMENSIONS IN INCHES	CHK	DWB 1/13/69
STANDARD TOLERANCES FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2°	ENG	1/14/69
FINISH TURNING TO .003 T.I.R ALL PIECES MUST BE CLEAN AND FREE FROM BURRS ALL THREADS CL-2 75% TH'D MIN	APP	1/14/69
USED ON 478A-3	MATERIAL	FINISH

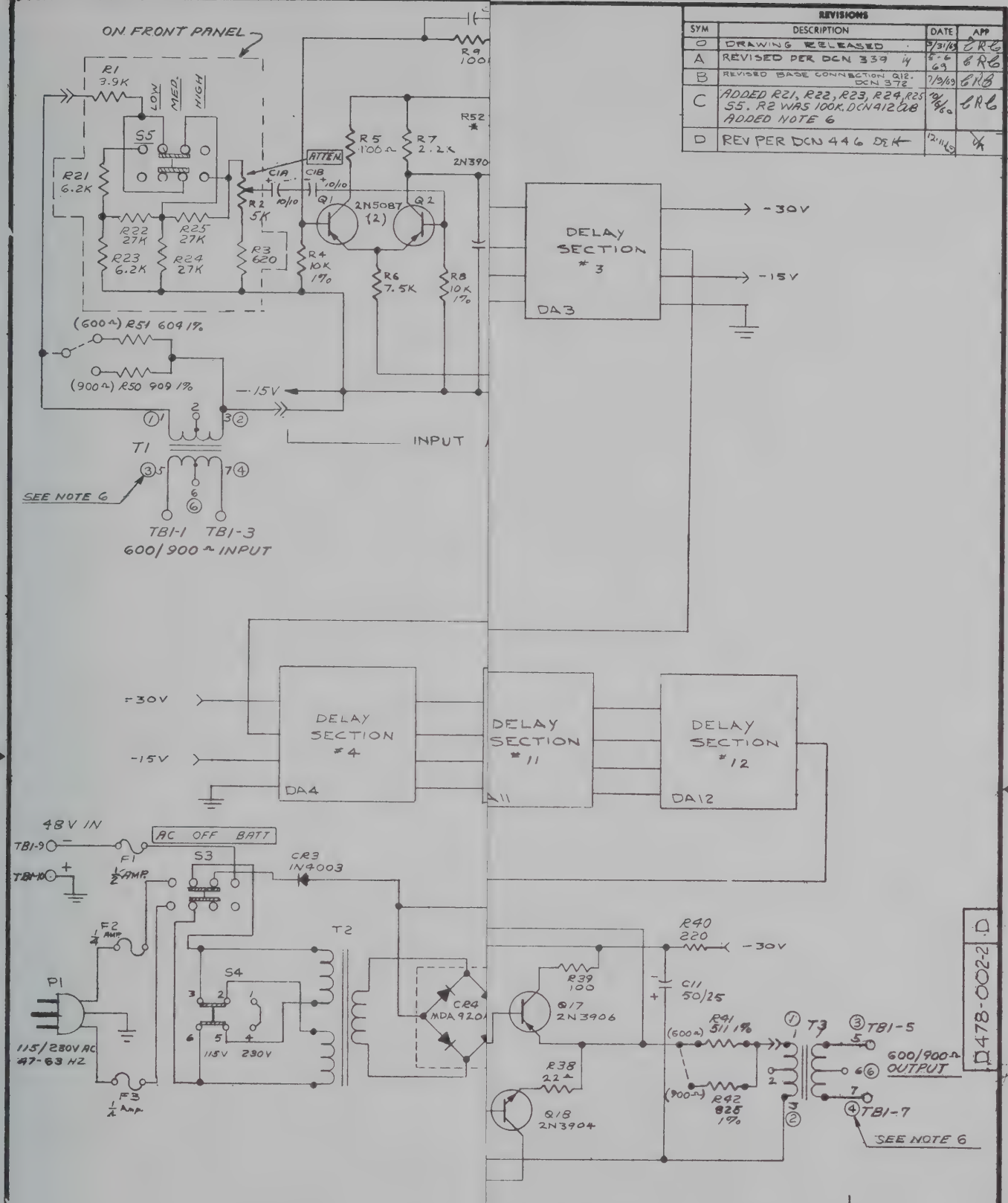
TITLE: DATA LINE CONDITIONER MAIN BOARD ASSEMBLY

ACTON LABORATORIES, INC. ACTON, MASS., U.S.A. SUBSIDIARY OF BOWMAR INSTRUMENT CORP

DWG. NO. C478-101-2 REV C

SCALE FULL | CODE #03860 | SHEET 1 OF 1

ACTON PRESS



REVISIONS			
SYM	DESCRIPTION	DATE	APP
O	DRAWING RELEASED	9/31/68	ERL
A	REVISED PER DCN 339 14	5-6-69	ERL
B	REVISED BASE CONNECTION Q18. DCN 372	7/9/69	ERL
C	ADDED R21, R22, R23, R24, R25 55. R2 WAS 100K. DCN 412 CAB ADDED NOTE 6	10/8/69	ERL
D	REV PER DCN 446 DEK	12.11.69	DK

NOTES
1. UNLESS OTHERWISE SPECIFIED:
   A. RESISTORS ARE IN OHMS; 1/2 W, @ 5 %
   B. CAPACITORS ARE IN MICROFARADS.
2. FOR LIST OF MATERIALS SEE LME
3. FOR ASSEMBLY SEE E478-001-2.
4. * SELECT AT TEST.
5. FOR RESONANT FREQ. 100 HZ LOWER TH NOMINAL, REMOVE STRAP "B TO E" & STRAP D TO E

	16·10·68	
	1/11/69	
	1/14/69	

REQD	ITEM	PART NO.	DESCRIPTION
LIST OF MATERIAL			

TITLE
478A-3
DATA LINE CONDITIONER
SCHEMATIC

LABORATORIES, INC.
ACTON, MASS., U.S.A.
A SUBSIDIARY OF BOWMAR INSTRUMENT CORP

DWG. NO. D478-002-2 REV. D

SCALE NONE | CODE #03860 | SHEET OF 1

D478-002-2 D

0

REVISIONS			
SYM	DESCRIPTION	DATE	APP
O	DRAWING RELEASED	9/31/68	ERG
A	REVISED PER DCN 339 4	6-6-69	ERG
B	REVISED BASE CONNECTIONS Q12. SCN 378	7/19/69	GHB
C	ADDED R21, R22, R23, R24, R25 S5. R2 WAS 100K. DCN 412 GHB ADDED NOTE 6	10/31/69	ERG
D	REV PER DCN 446 DSK	12/11/69	GHB

ON FRONT PANEL

R1 3.9K — LOW, MED, HIGH — S5

R21 6.2K

R22 27K

R25 27K

R23 6.2K

R24 27K

R3 620

R2 5K

C1A .10/10

C1B .10/10

ATTEN

R4 10K 1%

R5 100Ω

R7 2.2K

2N5087 (2) Q1 Q2

R6 7.5K

R8 10K 1%

R9 100K 1% — 14 pF

-30V

R52 *

R10 3.3K 1/4W

2N3904 Q3

Q4 2N3904

C2 .01

R11 470

CR1 1N914

C3 50/25

CR2 1N914

R12 15K

R13 7.5K

C4 .1/15

R16 100

R14 220

Q5 2N3906

R15 220

Q6 2N3904

R17 22

R18 220

R19 3.92K 1%

R20 2.43K 1%

(600Ω) R51 609 1%

(900Ω) R50 909 1%

-15V

INPUT AMP.

T1

SEE NOTE 6

TB1-1 TB1-3

600/900Ω INPUT

1R12 100

.01

AMPL.

131A

1R1 5K

1R4 3.3K

SEE NOTE 5

DEL AMP

DA1

1Q1 2N3906 (2) 1Q2

1R6 100

1R8 5.1K

1R7 15K

1R9 100

1R5 5K

1R10 1.8K

1R13 100

1Q3 2N3904

1C3 .01

1R11 15K

1Q4 2N3904

1R14 3.3K

OFF

ON

1S1B

SECTION ON-OFF

-30V

DELAY SECTION # 2

DA2

DELAY SECTION # 3

DA3

-30V

-15V

1R15 750

1R16 2.49K 1%

1R17 5K

1S2 DELAY RANGE

DELAY

ON FRONT PANEL

DELAY SECTION # 1

-30V

-15V

DELAY SECTION # 4 DA4

DELAY SECTION # 5 DA5

DELAY SECTION # 6 DA6

DELAY SECTION # 7 DA7

DELAY SECTION # 8 DA8

DELAY SECTION # 9 DA9

DELAY SECTION # 10 DA10

DELAY SECTION # 11 DA11

DELAY SECTION # 12 DA12

48V IN

TB1-9 (-)

TB1-10 (+)

F1 1/2 AMP.

AC OFF BATT

S3

CR3 1N4003

F2 1/2 AMP.

T2

S4

3 2 1 6 5 4

115V 230V

P1

115/230V AC 47-63 HZ

F3 1/2 AMP.

CR4 MDA 920A-3

HEAT SINK

Q8 2N4918

R43 24Ω 5W 10%

C5 850µf 75

C6 .01

CR5 1N5256

CR9 1N914

CR10 1N914

R53 7.5K

C7 50/50

Q9 2N4919

R44 130

R55 3.9K

R54 2.7K

Q13 2N4918

R56 10Ω

R58 3.6K

C13 50/25

C9 10/40

R59 10Ω

C12 50/25

Q12 2N4921

HEAT SINK

-30V

-15V

POWER SUPPLY

R27 18.2K 1%

R28 2.2K

R32 2.2K

R35 1.3K

Q14 2N3906 (2)

Q15 2N3906

Q16 2N3904

Q17 2N3906

R39 100

R40 220

-30V

C11 50/25

R26 2K 1%

R29 51Ω

R31 51Ω

R33 1.8K

C10 .01

CR6 1N914

CR7 1N914

R36 220

R38 22Ω

R30 7.5K

R34 15K

R37 220

Q18 2N3904

R41 511 1% (600Ω)

R42 825 1% (900Ω)

T3

TB1-5

600/900Ω OUTPUT

TB1-7

SEE NOTE 6

-15V

OUTPUT AMP.

D478-002-2 D

NOTES

1. UNLESS OTHERWISE SPECIFIED:
   A RESISTORS ARE IN OHMS; 1/2 W, @ 5 %; 1/4 W, @ 1 %.
   B CAPACITORS ARE IN MICROFARADS.
2. FOR LIST OF MATERIALS SEE LME 478-001-2.
3. FOR ASSEMBLY SEE E 478-001-2.
4. * SELECT AT TEST.
5. FOR RESONANT FREQ. 100 HZ LOWER THAN NOMINAL, REMOVE STRAP 'B TO E' & STRAP 'D TO E'.
6. USE NUMBERS IN CIRCLES FOR PIN CONNECTIONS WHEN ALLADIN TRANSFORMERS ARE USED FOR T1 AND T3.

REQD	ITEM	PART NO.	DESCRIPTION

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS IN INCHES
STANDARD TOLERANCES
FRACTIONS ± 1/64
DECIMALS ± .005
ANGLES ± 1/2°
FINISH TURNING TO .003 T I R
ALL PIECES MUST BE CLEAN AND FREE FROM BURRS
ALL THREADS CL 2 75% TH'D MIN

USED ON 478A-3

DR	Hdy.	10-10-68
CHK	[illegible]	1/11/69
ENG		
APP	[illegible]	1/14/69

MATERIAL

FINISH

TITLE
478A-3
DATA LINE CONDITIONER
SCHEMATIC

LABORATORIES, INC.
ACTON, MASS., U.S.A.
A SUBSIDIARY OF BOWMAR INSTRUMENT CORP

DWG. NO. D478-002-2 REV D

SCALE NONE | CODE #03860 | SHEET OF 1

O

SECTION 6

PARTS LIST

6.1 General

The parts lists contained in the following section itemizes by circuit number all electrical parts. Certain hardware items such as screws, washers, etc., are not included as these are readily identifiable and generally available. Generally, manufacturers' names have been included. However, in certain cases where the item is a standardized RETMA part, no manufacturer is designated and the product of the registered manufacturers should be acceptable.

Certain items within this parts list may contain Acton Laboratories (ALI) part numbers although they are not manufactured by Acton Laboratories, In such cases, these units are purchased to the ALI specification control drawing as indicated in the parts list.

FRONT PANEL AND CHASSIS MOUNTED PARTS (Schematic D478-002-2)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
TB1	Terminal Board	Kulka	600Y-10
T2	Transformer	Mystic	02-121
XF1, 2, 3	Fuseholder, 3AG	Littelfuse	342004
F2, 3	Fuse, 1/4 amp., "Slo-Blo"	Littelfuse	3AG
F1	Fuse, 1/2 amp. "Slo-Blo"	Littelfuse	3AG
C5	Capacitor, 850mfd, 75V	Sprague	36D851F075AA6C
R1	Resistor, 3.9K, 1/4W, 5%	A-B	EB3925
R3	Resistor, 620 ohm, 1/4W, 5%	A-B	EB6215
R2	Resistor, variable, 5K, 1W, 10%	Stackpole	C5845-4
1R15 through 12R15	Resistor, 750 ohm, 1/2W, 5%	A-B	EB7515
1R16 through 12R16	Resistor, 5.1K, 1/2W, 5%	A-B	EB5125
1R17 through 12R17	Resistor, variable, 5K, 1W, 10%	Stackpole	S6504 Blue
1R1 through 12R1	Resistor, variable, 5K, 1W, 10%	Stackpole	S6504 Red
1S1 through 12S1	Slide Switch, D.P.D.T.	Continental Wirt	G-126
1S2 through 12S2	Slide Switch, D.P.D.T.	Continental Wirt	G-126
S3, 5	Slide Switch, D.P., 3 Pos.	Continental Wirt	G-128-L
R21, 23	Resistor, 6.2K, 1/2W, 5%	A-B	EB6225
R22, 24, 25	Resistor, 27K, 1/2W, 5%	A-B	EB2735

MAIN BOARD ASSEMBLY (Schematic D478-002-2, Assembly C478-101)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
R4, 8	Resistor, 10K, 1/4W, 1%	Corning	NA60
R7, 28, 32	Resistor, 2.2K, 1/2W, 5%	A-B	EB2225
R6, 13, 30, 53	Resistor, 7.5K, 1/2W, 5%	A-B	EB7525
R9	Resistor, 100K, 1/4W, 1%	Corning	NA60
R33	Resistor, 1.8K, 1/2W, 5%	A-B	EB1825
R11	Resistor, 470 ohm, 1/2W, 5%	A-B	EB4715
R12, 34	Resistor, 15K, 1/2W, 5%	A-B	EB1535
R14, 15, 18, 36, 37, 40	Resistor, 220 ohm, 1/2W, 5%	A-B	EB2215
R16, 39, 5	Resistor, 100 ohm, 1/2W, 5%	A-B	EB1015
R17, 38	Resistor, 22 ohm, 1/2W, 5%	A-B	EB2205
R19	Resistor, 3.92K, 1/4W, 1%	Corning	NA60
R20	Resistor, 2.43K, 1/4W, 1%	Corning	NA60
R22	Resistor, 301 ohm, 1/4W, 1%	Corning	NA60
R26	Resistor, 2K, 1/4W, 1%	Corning	NA60
R27	Resistor, 18.2K, 1/4W, 1%	Corning	NA60
R29, 31	Resistor, 51 ohm, 1/2W 5%	A-B	EB5105
R35	Resistor, 1.3K, 1/2W, 5%	A-B	EB1325
R41	Resistor, 511 ohm, 1/4W, 1%	Corning	NA60
R42	Resistor, 825 ohm, 1/4W, 1%	Corning	NA60
R44	Resistor, 130 ohm, 1/2W, 5%	A-B	EB1315
R43	Resistor, 24 ohm, 5W, 10%	IRC	PW5
R10	Resistor, 3.3K, 1/4W, 5%	A-B	CB3325
1R4 through 12R4	Resistor, 3.0K, 1/2W, 5%	A-B	EB3025
R54	Resistor, 2.7K, 1/2W, 5%	A-B	EB2725

MAIN BOARD ASSEMBLY (Schematic D478-002-2, Assembly C478-101) (continued)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
1R5 through 12R5	Resistor, 5.6K, 1/2W, 5%	A-B	EB5625
1R8 through 12R8	Resistor, 5.1K, 1/2W, 5%	A-B	EB5125
1R7 through 12R7	Resistor, 15K, 1/2W, 5%	A-B	EB1535
1R11 through 12R11	Resistor, 15K, 1/2W, 5%	A-B	EB1535
1R9 through 12R9	Resistor, 100 ohm, 1/2W, 5%	A-B	EB1015
1R12 through 12R12	Resistor, 100 ohm, 1/2W, 5%	A-B	EB1015
1R13 through 12R13	Resistor, 100 ohm, 1/2W, 5%	A-B	EB1015
1R10 through 12R10	Resistor, 1.8K, 1/2W, 5%	A-B	EB1825
1R14 through 12R14	Resistor, 3.3K, 1/2W, 5%	A-B	EB3325
C1A, B	Capacitor, 10mfd, 10V	Seimens	B41313B3106Z
C2, 6, 10, C12, 13, 14	Capacitor Disc, .01mfd, 50V	Sprague	TG-S10
C4	Capacitor, 50mfd, 25V	Seimens	B41283J5506T
Q1, 2	Capacitor, .1mfd, 75V	Centralab	DDA104
C7	Transistor		2N5087
C9	Capacitor, 50mfd, 50V	Seimens	B41283C6506T
	Capacitor, 10mfd, 40V	Seimens	B41313B71062
	Capacitor, 10mfd, 50V	Sprague	TE1304

MAIN BOARD ASSEMBLY (Schematic D478-002-2, Assembly C478-101) (continued

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
1C3 through 12C3	Capacitor, .01mfd, 100V	C-D	WMF1S1
CR1, 2, 6, 7, 9, 10	Diode		1N914
CR3	Diode		1N4003
CR5	Diode, Zener		1N5256
CR4	Bridge Rectifier	Motorola	MDA920A3
Q4, 5, 7, 14, 15, 17	Transistor		2N3906
1Q1 through 12Q1			
1Q2 through 12Q2			
1Q4 through 12Q4			
1R6 through 12R6	Resistor, 100 ohm, 1/2W, 5%	A-B	EB1015
Q3, 11, 16, 18, 6	Transistor		2N3904
1Q3 through 12Q3	Transistor		2N3904
Q8, 13	Transistor	Motorola	2N4918
Q12	Transistor	Motorola	2N4921
T1, 3	Transformer	ADC (or Alladin)	1242H (S/O8065)
R52	Resistor, 2K through 7.5K, 1/2W, 5%	A-B	Select
Q9	Transistor	Motorola	2N4919
DA1	Delay Network, .6kHz		C4781031A
DA2	Delay Network, .8kHz		C4781031B
DA3	Delay Network, 1.0kHz		C4781032
DA4	Delay Network, 1.2kHz		C4781033
DA5	Delay Network, 1.4kHz		C4781034
DA6	Delay Network, 1.6kHz		C4781035
DA7	Delay Network, 1.8kHz		C4781036

MAIN BOARD ASSEMBLY (Schematic D478-002-2, Assembly C478-101) (continued)

SYMBOL NUMBER	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
DA8	Delay Network, 2.0kHz		C4781037
DA9	Delay Network, 2.2kHz		C4781038
DA10	Delay Network, 2.4kHz		C4781039
DA11	Delay Network, 2.6kHz		C47810310
DA12	Delay Network, 2.8kHz		C47810311
S4	Switch, 115 - 230 VAC	Switchcraft	46256LF
1C4 through 12C4	Capacitor, .01mfd, 500V		CK63AW103M
R58, 59	Resistor, 10 ohm, 1/2W, 5%		EB1005
R57	Resistor, 1.5K, 1/2W, 5%		EB1525
R55	Resistor, 3.9K, 1/2W, 5%	A-B	EB3925
R56	Resistor, 3K, 1/2W, 5%	A-B	EB3025
R50	Resistor, 909Ω, 1/4W, 1%	Corning	NA60
R51	Resistor, 604Ω, 1/4W, 1%	Corning	NA60

LIST OF MANUFACTURERS

Abbreviation	Complete Name and Address
A-B	Allen Bradley Company 1201 S. Second Street Milwaukee, Wisconsin 53204 USA
ADC	ADC Products 6405 Cambridge Street Minneapolis, Minnesota 55426 USA
C-D, CDE	Cornell Dublier Electronics 50 Paris Street Newark, New Jersey 07101 USA
Continental Wirt	Continental Wirt Corporation 26 W. Queen Lane Philadelphia, Pennsylvania 19144 USA
Corning	Corning Glass Works Houghton Park Corning, New York 14830 USA
Centralab	Centralab 5757 North Greenbay Avenue Milwaukee, Wisconsin 53209 USA
IRC	International Resistor Corporation Division of TRW 401 N. Broad Street Philadelphia, Pennsylvania 19108 USA
Kulka	Kulka Electric Corporation 520 South Fulton Avenue Mount Vernon, New York 10551 USA
Littelfuse	Littelfuse, Inc. 800 E. Northwest Highway Des Plaines, Illinois 60016 USA
Mystic	Mystic Transformers, Inc. 114 West Street Wilmington, Massachusetts 01887 USA

Abbreviation	Complete Name and Address
Siemens	Siemens Components Division 230 Ferris Avenue White Plains, New York 10603 USA
Sprague	Sprague Electric Company 125 Marshall Street North Adams, Massachusetts 01247 USA
Stackpole	Stackpole Components Company P. O. Box 14466 Raleigh, North Carolina 27610 USA
ALI	BOWMAR/ALI, INC. (formerly Acton Laboratories, Inc.) 531 Main Street Acton, Massachusetts 01720 USA

SECTION 7

SUPPLEMENTARY DATA

7.1 Guarantee

Acton Laboratories, Incorporated guarantees to the original purchaser that this instrument is in accordance with applicable specifications. Any deviation from those specifications or defects of workmanship or material will be corrected by Acton Laboratories, Inc., provided the instrument has been properly used under normal operating conditions. This guarantee is in effect to the original purchaser for one year from date of shipment, except for failures of or attributable to tubes, fuses, batteries, or semiconductors after 90 days from date of shipment. Acton Laboratories, Inc. will be the sole judge of the validity of all claims.

All returns made under this guarantee must be authorized in writing by Acton Laboratories, Inc. Such authorization will be given only upon receipt of information concerning type, serial number, and the defect claimed. Return shipments must be made prepaid except returns authorized within 30 days from date of shipment, in which case, Railway Express Collect will be authorized. All rework done under this guarantee will be re-shipped from our plant Railway Express prepaid.

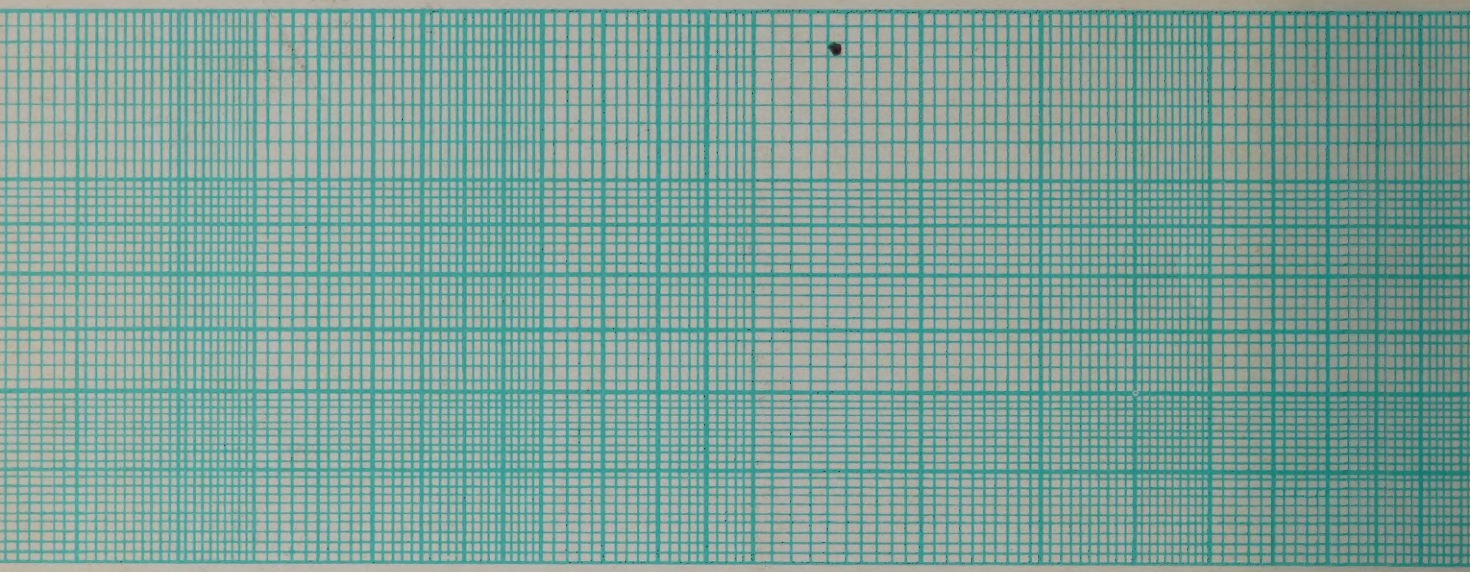
Acton Laboratories, Inc. will not be held responsible or assume any expense or liability for damage of loss in shipment, loss of profit or any other damages or claims for which provisions are not specifically made herein.

7.2 Material Damaged in Shipment

Address correspondence to:

Acton Laboratories, Inc.
531 Main Street
Acton, Massachusetts, U.S.A. 01720
Telephone: 617-263-7756

If upon receipt of your instrument, the packing case shows evidence of damage, or if upon unpacking, damage is found which appears to have been caused by shipment, do not unpack or discard any of the packing. Notify immediately the local office of the carrier and request that they inspect the damage. Also, notify Acton Laboratories, Inc. of the type number, serial number, carrier's number, date received, and any other pertinent information so that we may contact our own local carrier office in order to facilitate a speedy settlement of any claims.



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Laboratories, Inc.

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ACTON, MASSACHUSETTS
Acton 617-263-7756 • 531 Main Street • Boston 617-542-0284